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Combining direct residence time measurements and biogeochemistry to calculate in-situ reaction rates in the hyporheic zone

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The hyporheic zone is an active interface between groundwater, riparian and surface water systems. Exchange and reaction of water, nutrients, and organic matter occur due to variations in surface and groundwater flow regimes, bed topography and active biogeochemistry fuelled by bioavailable carbon. There has been an increasing focus on coupling the residence time of surface water in the hyporheic zone with biogeochemical reactions. However, there are very few tracers that can be used to measure residence times in-situ, especially in complex groundwater-surface water settings. In this work we have used the natural radioisotope Radon (222Rn) as an in-situ tracer for river water residence time in a riffle-pool sequence (Rote Main River), and combined this information with biogeochemical parameters (DOC and C quality, O_3, NO_3, CO_2). We can clearly observe a dependence of reaction progress on the water residence times, with oxygen and nitrate reduction following inverse logarithmic trends as a function of time. By comparing with initial concentrations (the river end member) with riverbed levels we have estimated first-order in-situ reduction rates for nitrate and oxygen. Nitrate reduction rates are at the higher end of published values, which is likely due to the continual supply of bioavailable carbon from the river system. This work helps to better understand the function and efficiency of the hyporheic zone as a natural filter for redox sensitive species such as nitrate at the groundwater – steam interface. It also provides a useful method for estimating residence times in complex, higher order river systems.